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Classification of Subjective Symptoms of Junior High School Students Affected by Photochemical Air Pollution

Environmental Protection Agency, Research Triangle Park, N C

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CLASSIFICATION OF SUBJECTIVE SYMPTOMS OF JUNIOR HIGH
SCHOOL STUDENTS AFFECTED BY PHOTOCHEMICAL AIR POLLUTION
[Kōgaku sumoggu ni yoru jikaku shōjō no bunrui]

by

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Epidemiological studies on the subjective symptoms of students
affected with photochemical air pollution were made in the periods
of Sept. 13, 21, 22, 1972 (School A), and on Oct. 3 (School B) in
Osaka.

A statistical analysis following Hayashi's Quantification
Theory (Pattern Classification) revealed that the symptoms were
to be classified into three types: Type A with a chief com-
plaint of eye irritation, Type B complaining of cough and sore
throat, and Type C with nausea, dizziness, and numbness of the
extremities.

Those three types were either interchangeable or overlapping
depending upon the time and day of examination.

Difference in type classification seems to show a difference in the
quality of photochemical air pollution.

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PRICES SUBJECT TO CHANGE

1. Introduction

On the subject of the effects of air pollution caused by photochemical reactions (hereafter referred to as photochemical air pollution), there have already been many reports [1 - 4] including those on cases found in Los Angeles. In our country too, there have been successive reports of health damage from many parts of the country ever since damage to the health of students at Risshō High School in Tokyo became a focus of nation-wide attention in July of 1970 [5, 6]. It is however said that the properties of photochemical air pollution in our country may not necessarily be the same as those of the Los Angeles smog. The true picture of the properties is gradually becoming clearer through the publication of such reports as one indicating that respiratory alkalosis is observed in cases which are accompanied by such serious symptoms as intrathoracic oppression and numbness of the extremities [7]. It would nevertheless seem necessary to organize and analyze data on phenomenon-related aspects of health damages if one were to properly understand the wide variety of symptoms.

Against this background, it so happened that there was a high incidence of symptoms apparently caused by photochemical air pollution at a junior high school in Osaka Prefecture on altogether three occasions on 13th, 21st and 22nd of September in 1972. The Prefectural Public Health Department, the Health Clinics and various Osaka municipal agencies concerned with environmental pollution conducted questionnaire surveys of the students in an effort to obtain a clear picture of the subjective symptoms. In addition, there was a high incidence of such symptoms as numbness of the extremities at another junior high school on October 3 of the same year and similar surveys were again

conducted. This report will discuss the subjective symptoms due to photochemical air pollution from the epidemiological standpoint on the basis of the results of these surveys.

2. Subjects and Method of Surveys

2.1 Outline of Health Damages

School A, where health damages were reported in September, is situated in the southern part of Osaka Prefecture some 1.3 km southeast of the coastline. On September 13 (hereafter referred to as the first incidence), many of the students from two classes which had a physical education class [Translators note: The term "gymnastic lesson" is used in English-language captions to the figures in the original.] for the fifth period (13:10 - 14:00) complained of such symptoms as smarting eyes and coughing and were treated in the school clinic. Similar complaints came from many of the students taking physical education for the sixth period (14:10 onward) so that the school suspended the class and notified the Prefectural authorities, attributing the symptoms to photochemical air pollution. Subsequently, many of the students at the same school complained of such symptoms as eye irritation during regular classes held indoors on September 21 (second incidence) and 22 (third incidence).

School B is situated in an inland area in the northern part of Osaka Prefecture. At this school, second year students [Translator's note: eighth graders] were participating in a joint practice for a field day from about 10:30 on October 3 when many of the students began to complain of such symptoms as numbness of the extremities and smarting eyes. Of these students,

18 of them were suffering from relatively serious symptoms so that they had to be admitted to the Kansai University of Medicine hospital [8] where they were treated.

In addition, there were other reports of symptoms from other schools in Osaka Prefecture, which is to say four schools on September 21, two schools on September 22 and one school on October 3, but all of these involved sporadic incidences involving less than ten students each time.

2.2 Survey Procedure

The questionnaire surveys were conducted through teachers in charge of the classes concerned either on the day of the incidence or damages or on the following day. The survey subjects consisted of the entire student body from the first to the third year (1313 students enrolled) in the case of school A, and only the second year students from school B where the victims had been limited only to the second year students who were on the athletic ground. For the questionnaire form, we used the "Survey Form on the Effects of Photochemical Air Pollution" prepared by the Public Health Department of the Osaka Prefectural Administration. The substance of the questions was the presence or absence of subjective symptoms with respect to the nine items, i) smarting of the eyes, lachrymation, ii) sore throat, iii) coughing, iv) sputum, v) chest discomfort, vi) dizziness, vii) nausea, viii) numbness of the extremities, and ix) headache.

It should be noted that the exact number of students surveyed at school A is not known since the questionnaire forms were collected only from those who had complained of symptoms. However, since the survey was carried out more or less with respect to all students enrolled, we decided to adopt the the number of students enrolled as the total number of subjects surveyed.

In the case of school B, 25 students who were either hospitalized or recovering at home on the day of the survey were not included. The result of the questionnaire survey therefore only presented the pathological image of, so to speak, the peripheral group which did not include the serious cases. It is therefore necessary to take this point into account in interpreting the result obtained from school B.

2.3 General Condition of Air Pollution

According to the available data from Osaka Prefecture and municipal authorities, the conditions of air pollution on the days of reported damages were as follows.

During the periods in question, stations at which monitoring was being conducted on a regular basis included two points relatively close to school A, namely a spot about 600 m to the northwest of the school (hereafter referred to as station O) and a spot about 1,000 m away in the same direction (hereafter referred to as station P). Station O was monitoring the oxidant concentration, while station P was monitoring sulfur oxides, NO and NO₂ as well as the oxidants. It so happened, however, that station P was not monitoring on September 21 or 22, so that we were only able to obtain data for September 13.

Fig. 1 shows concentrations monitored at station P on September 13. The oxidant concentration reached its maximum level of 0.14 ppm at 1500. Both NO and NO₂ reached their maximum concentrations of 0.17 ppm and 0.12 ppm respectively at 1400 while the sulfur oxide concentration registered its highest level of 0.06 ppm at 1300. The atmospheric temperature reached its maximum of 29.4°C at 1100. On the other hand, the concentrations monitored

at station O on the same day were generally higher than those at station P with the oxidant concentration reaching 0.19 ppm between 1400 and 1500. It is worth noting that there was a considerable difference in concentrations between the two stations relatively close to each other on that day.

On the 21st, the highest pollutant concentration at station O was 0.17 ppm at 1300 and on the 22nd, it was 0.11 ppm at 1200 (Fig. 2).

In the case of school B, the nearest monitoring point was about 1300 m away in the direction of west by northwest. The maximum oxidant concentration at that station on October 3 was 0.09 ppm. Also, a monitoring vehicle happened to be recording the pollutant concentrations at a point about 300 m to the northeast of the school on that day, but the maximum concentration was only 0.07 ppm. Both of these maximum concentrations may be considered comparatively low. The atmospheric temperature was 26.9°C at 1300 on that day and there were no reports of accidents involving toxic gases and so on around the school.

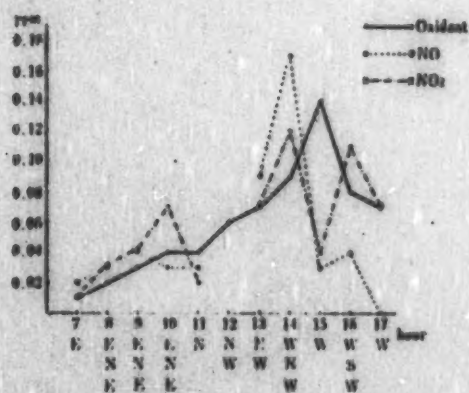


Fig. 1 Air pollution on Sep. 13 at station P.

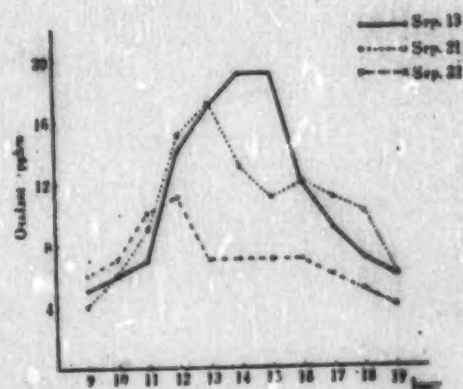


Fig. 2 Oxidant at station O.

3. Survey Results

3.1 Complaint Rates at School A

The rates of those who complained of some sort of symptoms such as eye irritation and sore throat in the questionnaires with respect to the total number of enrollment (hereafter referred to as complaint rates) were 263 out of the total enrollment of 1313 (20.0%) for the first incidence, 133 (10.1%) which is to say about one-half of the first rate for the second incidence, and 72 (5.5%) which is again about one-half of the previous number for the third incidence.

Of the altogether three incidences of symptoms, the complaint rate for the first incidence was characteristically correlated with the timing of the physical education classes. Fig. 3 shows the relation between the timing of physical education classes and the complaint rate. The symptoms occur frequently in those who had physical education classes after the third period [Translator's note: The term "school hour" is used in English captions accompanying the figures in the original.], increasing gradually from 21.1% for the third period (10:30 - 11:20) to 36.9% for the fourth period (11:30 - 12:30) and to the fifth period (13:10 - 14:00) in particular for which 50.9% of the students who had physical education complained of some sort of symptoms. Incidentally, all of the physical education classes on that day were held on the athletic ground but the students were not subjected to physical exercise any more rigorous than normal. It should also be noted that classes for the various periods were continued without notification of the authorities about the occurrence of pollution-related victims.

The fluctuation in the complaint rates was thus found to be correlated with the condition of air pollution. As indicated earlier in Fig. 1, the data from station P shows that the wind direction which was ENE at 1000 changed to N at 1100, and then shifted again before 1500 from NW to W. The oxidant concentration increased gradually after 1100 when there was a shift in the wind direction, and, in correspondence with this increase, the complaint rate also increased as shown in Fig. 3.

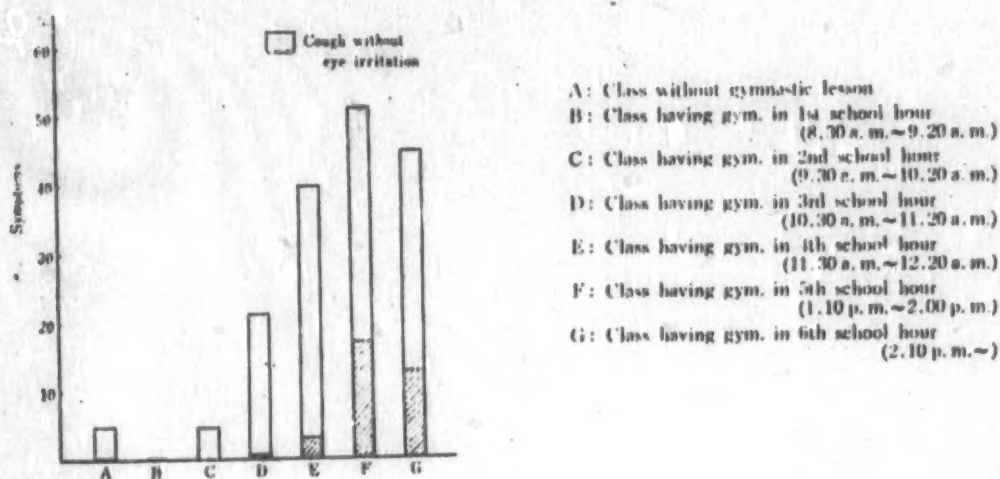


Fig.3 Symptoms and gymnastic lesson.

In contrast, there was no special correlation with the timing of physical education classes in the case of the second incidence and the third incidence in which students complaining of symptoms were distributed randomly among the different school years and classes. Also, there was no noteworthy characteristic in terms of the distribution of the classrooms in the school building. It is believed that such variances from the first incidence are connected not only with differences in pollutant concentrations, but also with such factors as the meteorological conditions, but we were unable to

determine the exact causes. As far as the differences between the complaint rates for the different incidences are concerned, a straight forward comparison is not possible since proper assessment of the actual exposure conditions would be required. One may nevertheless compare the second and the third incidences for a rough guideline in the following manner. The maximum oxidant concentration value for the second incidence was 0.17 ppm while that for the third incidence was 0.11 ppm so that the ratio would be approximately 1.5:1, and, in correspondence with this ratio, the ratio between the complaint rates for the second and the third incidences was about 1.8:1.

3.2 Distributions of Symptoms

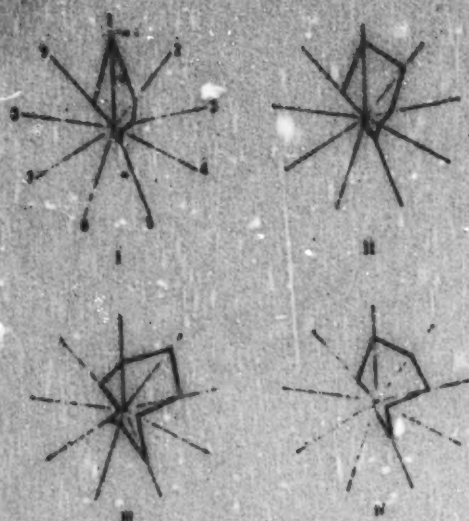
Of the symptoms reported in the first incidence, "smarting of eyes and lachrymation" was the most frequent in being reported by 70.3% of all the complainants, and this was followed notably by "sore throat" with 63.9% and "coughing" with 42.6%. The other percentages were 36.9% for "chest discomfort", 32.7% for "headache", 12.5% for "sputum", 9.5% for "dizziness", 7.6% for "nausea" and 1.1% for "numbness of the extremities". These symptoms may be considered typical of the photochemical air pollution symptoms reported from time to time in our country.

As far as the first incidence is concerned, however, the distribution of the symptoms as well as the complaint rate varied from one class to another with a definite correlation to the timing of the physical education classes. In the classes which did not have physical education on the day in question and the classes which had physical education by the third period, the main complaint was such eye irritation symptoms as "smarting of eyes

and lachrymation", a complaint which came from 94.6% of the total number of complainants. "Sore throat" and "coughing" occurred relatively infrequently at 37.5% and 19.6% respectively. In addition, in the classes which had physical education for the fifth period and which registered the highest complaint rate, those complaining of eye irritation symptoms were relatively few at 50.0% of the total number complainants, while "sore throat", "coughing" and "chest discomfort" were notably frequent at 81.0%, 60.7% and 59.5% respectively.

In the aforementioned Fig. 3, which indicates the relation between the timing of the physical education classes and the complaint rate, the shaded portions of the bars indicate the percentages of those who complained of coughing but suffered no eye irritation. These portions increase rapidly in the classes having physical education in the fifth and sixth periods to constitute a major characteristic of the symptoms of these classes.

Fig. 4 divides the classes into four groups on the basis of the physical education periods and indicates the distribution of the symptoms for each of the groups. For each group of classes, the percentages of the different symptoms reported by the complainants are shown. There is a clear difference between the distribution pattern of the symptoms in the group of classes which did not have physical education or had it by the third period (hereafter referred to as Type A) and the distribution patterns for the groups of classes having physical education in the fifth and sixth periods (hereafter referred to as Type B) with the class having physical education in the fourth period showing what may be called a transitional pattern. The patterns for the second and third incidences were all Type A patterns.



- I: Class without gymnastic and having gym. in 1st-2nd school hour
 II: Class having gym. 4th school hour
 III: Class having gym. in 3rd school hour
 IV: Class having gym. in 6th school hour
- | | |
|--------------------------------|------------------------------------|
| Symptoms No. 1: eye irritation | No. 2: sore throat |
| No. 3: cough | No. 4: sputum |
| No. 5: chest discomfort | No. 6: dizziness |
| No. 7: nausea | No. 8: numbness of the extremities |
| No. 9: headache | |

Fig. 4 Symptoms by the class in School A, Sep. 13.

In terms of the individuals, several symptoms are sometimes reported together. There were altogether 196 respondents who complained of at least one of the symptoms of, "sore throat", "coughing" and "chest discomfort", but of these, 127 individuals, or 64.8%, complained of two or three of these symptoms together. This percentage exceeded the expected value with the level of significance at 5%. Meanwhile, there were 185 individuals who complained of eye irritation symptoms, and of this number, 45 individuals, or 23.2% complained only of eye symptoms. This figure was again significantly in excess of the expected value.

In Fig. 5, the percentages of the different symptoms reported in addition to the eye symptoms and in addition to coughing are indicated with the exclusion of numbness of the extremities which had only occurred in a few cases. For example, of those students who complained of headache, it is seen that 75.6% also suffered from eye symptoms and 44.2% also suffered from coughing. The percentages representing such combinations of the symptoms

vary according to the symptoms involved, thus indicating that the combinations of the symptoms follow certain fixed trends.

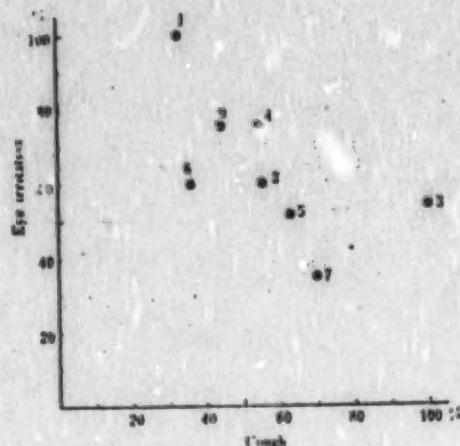


Fig. 5 Symptoms combined with eye irritation or cough.
(Symptoms No. 1~9 are described in Fig. 4)

3.3 Pattern Classification of Symptoms

On the basis of the above observation, we sought to classify the subjective symptoms caused by photochemical air pollution into several patterns through the examination of the relations between the different symptoms by applying method Category III of Hayashi's quantification theory [9, 10].

Fig. 6 shows the result of calculation conducted with respect to all the complainants from the first incidence.¹ We adopted the two-dimensional development of X_1 and X_2 axes. This graph shows that the closer the symptoms

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1. The presence or absence of the symptom was calculated separately for each symptom as an independent item. For the sake of simplicity, only the cases in which the symptoms were present were indicated in the graph.

are to each other with respect to the X_1 axis, the more closely they are related to each other, and that of the closely related symptoms, the ones that are closer to each other with respect to the X_2 axis as well are even more closely related to each other. It is seen from this graph that the eye irritation symptom alone is positioned in the third quadrant away from the others, while a group consisting of "coughing", "chest discomfort" and "sore throat" is, in contrast, more or less concentrated in the first quadrant. Away from these two groups, a group consisting of what one may call nervous symptoms, namely "dizziness", "headache" and "numbness of the extremities", establishes a third group in the fourth quadrant. It is further noted that sputum, in variance to coughing, is positioned in the fourth quadrant, thus indicating that coughing due to photochemical air pollution is not necessarily accompanied by sputum.

Fig. 7 is a dendrogram obtained by further developing the relations between the symptoms in three dimensions in terms of the X_1 , X_2 and X_3 axes and then analyzing the relative distances between the symptoms by stratified cluster analysis using the nearest neighbor method [11]. According to the dendrogram, the symptoms are organized into four groups, namely (i) eye irritation, (ii) sore throat, coughing, chest discomfort, (iii) headache, dizziness, (sputum), and (iv) nausea, numbness of the extremities.

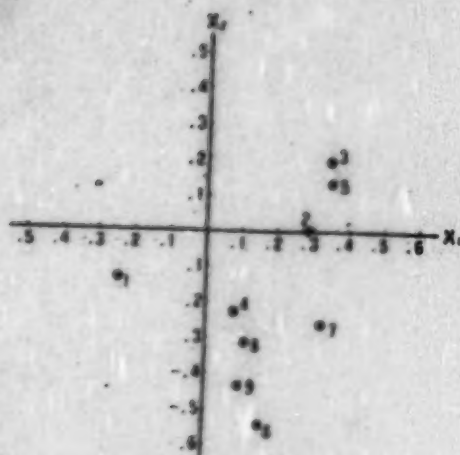


Fig. 6 Grouped symptoms by quantification theory (pattern classification) on Sep. 13 in School A. (Symptoms No. 1-9 are described in Fig. 1)

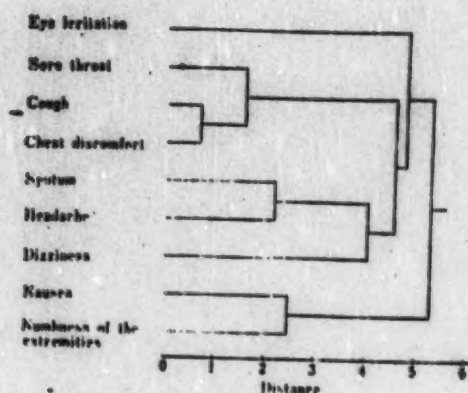


Fig. 7 Dendrogram of symptoms on Sep. 13 in School A.

As stated already, the symptom patterns were found to vary according to the timing of the physical education classes. Fig. 8 shows the transitional changes in the positions of the "eye irritation" and "sore throat" symptoms due to the timing of the physical education class in terms of the two-dimensional representation by the X_1 and X_2 axes. The two symptoms were found to move in opposite directions up to the fifth physical education period. The "eye irritation" symptom was found to differ from the other symptoms in that all symptoms other than the "eye irritation" symptom moved in directions similar to the direction of the "sore throat" symptom. In addition, the distribution of the individual values by the class group on the X_1 axis [by Hayashi's theory] is shown in Table 1. (For example, if a student complains of "eye irritation" and "sore throat" symptoms, the quantity for the "eye" symptom on the X_1 axis would be - 0.2457 and the quantity for the "throat" symptom + 0.2847 and the total quantity for the other seven symptoms

of which there were no complaints would be - 0.8147, therefore, the total value for the nine symptoms would be - 0.7757 and the mean value - 0.086. The individual quantity for the student in question was therefore assumed to be - 0.086.)



Fig. 8 Symptom values subject to change depending upon gymnastic lesson.
(Class I-IV are described in Fig. 4)

A comparison of the distribution ranges of highest individual quantity values showed that the range was under - 0.10 for classes which either had no physical education or had physical education by the third period, from - 0.09 to 0.05 for classes taking it in the fourth period, and from + 0.05 to 0.09 for classes taking it in the fifth and sixth periods. This comparison thus also indicates that the individual quantities did vary according to the timing of the physical education classes to cause changes in the distribution of the symptoms.

Table 1 Distribution of individual values calculated by Heynshi's quantification theory.
(Class I-IV are described in Fig. 4)

Value	Class	I	II	III	IV
+0.10~		1(1.0)	2(3.1)	22(26.2)	9(15.3)
+0.05~+0.09		3(5.4)	9(13.8)	29(34.5)	15(25.9)
0~+0.01		5(8.3)	7(10.8)	4(4.8)	3(3.4)
-0.01~0		3(5.0)	10(15.4)	13(17.9)	11(19.0)
-0.05~-0.09		11(25.0)	22(31.8)	8(9.5)	7(12.1)
~ -0.10		20(31.6)	13(20.1)	6(7.1)	11(21.1)
Total		56(100)	63(100)	81(100)	56(100)

(%)

3.4 Symptoms at School B

The individuals surveyed at school B numbered 248. Of these, there were altogether 152 individuals, or 61.3% who complained of some sort of symptoms. By sex, 76 individuals or 53.5% of the 142 male students and 76 individuals or 71.7% of the 106 female students complained of symptoms. As stated in the beginning, the survey data from school B excluded students who were either hospitalized or recuperating at home on the day of the survey. Since most of such students were female students, the complaint rate for the female students would have been higher if these students had been included. This was one of the differences compared to school A whose complaint rates by sex for the first incidence were 54.0% for male students and 57.1% for female students, a difference not so significant.

The distributions of the symptoms also varied considerably from that of school A. To wit, such nervous system related symptoms as "headache", "dizziness", "nausea" and "numbness of the extremities" were prominent among the symptoms reported with 52.0%, 31.6%, 25.0% and 7.9% respectively, while the "eye irritation" symptom was reported by only 21.7% of those who complained of some sort of symptoms (Fig. 9). In terms of differences between the sexes, 23 of the 27 students complaining of "chest discomfort" and 10 of the 12 students complaining of "numbness of the extremities" were female students. Female students also constituted high percentages with "nausea", "headache" and "sore throat", but there was no sex difference with "eye irritation" or with "coughing".

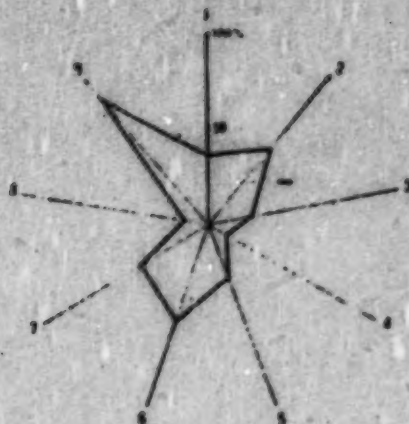


Fig. 2 Symptoms in School B, Oct. 2.
(Symptoms No. 1-9 are described in Fig. 1)

As a matter of interest, female students at school A also constituted high percentages in the symptoms of "dizziness", "nausea" and "headache" while there was no difference between the sexes with "eye irritation", "sore throat" or "coughing". In other words, the female students throughout both schools exhibited high complaint rates in terms of what one may call nervous system symptoms, while there was no significant sex difference in terms of such symptoms as eye irritation.

It should also be noted that the average number of symptoms per one complainant was 2.7 for males and 2.9 for females in school A so that there was not much difference between the sexes, while it was 1.6 for males and 2.5 for females in school B, indicating a significant increase in the females. This would seem attributable to the fact that there was a high frequency of the eye irritation symptom, which involved no sex difference, in school A while there was a high frequency of nervous system symptoms, which tended to affect the female students more, in school B.

The pattern of symptoms at school B (hereafter referred to as Type C) illustrates the characteristic of the so-called serious cases which constitute one of the major problems of the photochemical air pollution type which occurs in our country. What must be considered significant in this connection is the relationship between Types A and B and Type C. In this respect, the symptoms of the classes at school A, which had physical education in the fifth period are worth noting. These classes exhibited not only a high frequency of coughing, which is a characteristic of Type B, but also percentages of 14.3% and 19.0% respectively for "dizziness" and "nausea", symptoms which are among the characteristics of Type C. The latter percentages were considerably higher compared to the average values of 7.3% and 2.2% exhibited respectively for the same symptoms by other classes at school A. Furthermore, the class in question was the only one to include complaints of "numbness of the extremities", although the symptom was not serious. Is it not possible that the symptoms in this class were in a transitional phase progressing toward Type C?

Fig. 10 shows the pattern classification of the symptoms at school B obtained by the Category III quantification method. It is shown in two dimensions in terms of the X_1 and X_2 axes. The graph shows the "eye" symptoms on the (-) side of the X_1 axis, the "dizziness" and "numbness" symptoms in the first quadrant and the "sore throat" symptom in the fourth quadrant to indicate that these are all separate symptom groups.

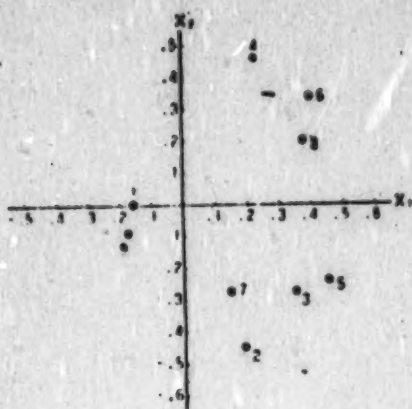


Fig. 10 Grouped symptoms by quantification theory
(pattern classification) on Oct. 3 in School B.
(Symptoms No. 1~7 are described in Fig. 1)

Fig. 11 shows a dendrogram obtained by further developing the pattern in three dimensions and then analyzing the distances between the symptoms by cluster analysis. In this case, the dendrogram shows five groups consisting of (i) eye, (ii) headache, (iii) throat, coughing, (iv) chest discomfort, nausea, and (v) sputum, dizziness, numbness of the extremities. Comparison with the dendrogram for school A shows that although the positions of the "headache" and "chest discomfort" symptoms vary, the basic distribution of the other symptoms is more or less in agreement as these symptoms fall into the three general groups of (i) eye irritation, (ii) sore throat, coughing, and (iii) nausea, numbness. It would seem that the variance between the pathological images of the two schools depended on which ones of the three groups were predominant.

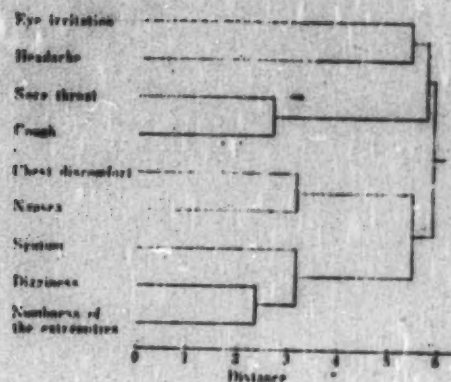


Fig. 11 Dendrogram of symptoms on Oct. 3 in School B.

3.5 Recurrence of Complainants

We decided to examine the trends regarding the recurrence of complainants with respect to school A where there had been three incidences of symptoms within a relatively short period.

In terms of the number of classes, the classes which had complainants for any two of or all three of the incidences constituted 22 classes out of the total number of 31 classes in the school, or 71.0%. This percentage was more or less in agreement with the expected value, and no cluster trend in terms of the number of classes could be detected.

In terms of the individual students, however, a trend of recurring complainants was observed with those who complained of symptoms in the first incidence as well as in the second and third incidences constituting 63 students out of 207 or 30.4% (males 28 students out of 106, or 26.4%, and females 35 students out of 101, or 34.7%), and those who did not complain of symptoms in the first incidence but did complain in the second or third incidence

constituting 37 students out of 252 or 14.7% (males 23 students out of 126, or 18.3%, and females 14 students out of 126, or 11.1%). This trend was particularly pronounced among the female students. In particular, eight of the nine students who complained of symptoms in all three incidences were females.

In terms of the number of symptoms reported by individual complainants, the average number of symptoms reported in the first incidence by those who also complained of symptoms in the second and third incidences was 3.0 and the average number of symptoms reported in the first incidence by those who only complained of symptoms in the first incidence was 2.9, so that there was no significant difference. However, in terms of the number of symptoms reported in the second and third incidences, the average number of symptoms for those who had also complained of symptoms in the first incidence was 2.3, while the average number for those who had experienced no symptoms in the first incidence was 1.9, showing a tendency for the symptoms to become somewhat numerous among the recurring complainants. In terms of the symptoms themselves, the data for the second incidence, for example, shows that while "sore throat" was reported by 45.8% of those who only had symptoms in the second incidence, it was reported by a higher 67.2% of the recurring complainants ($p < 0.05$). In addition, there was a tendency for "coughing", "chest discomfort", "dizziness" and "nausea" to occur more frequently among the recurring complainants.

4. Discussion

The symptoms caused by photochemical air pollution are probably composite effects of a complex of pollutants and are affected by such environmental conditions as temperature. There are also individual conditions such as the

amount of physical exercise. It would, consequently, be premature to attempt to define the symptoms caused by photochemical air pollution in our country on the basis of a small number of cases. This report, too, only concerns some cases which happened to occur in Osaka Prefecture. If we may, however, dare to risk a deduction on the basis of the results of this survey, the following points may be conceivable in terms of the relationship between the pollutants and the symptoms.

What must first be considered are the conditions under which the Type C symptoms (numbness of the extremities, dizziness, nausea, etc.) occur. Assuming that the symptoms of the classes having physical education in the fifth period at school A are those of a transitional phase on the way to Type C, the symptoms in question are found to occur at the time when the oxidant concentration is about to reach its highest level. However, in the case of school B, which may be considered typical of Type B, the oxidant concentration was in fact generally low although the monitoring point was relatively far away. Would it not be possible, then, that the casual substances in Type C may have been formed either at the peak or, more likely, after the peak in the formation of the oxidants? Also, the transition phase to the Type C symptoms was not observed in school A classes having physical education in the sixth period. Even in the case of school B, there were other schools in the same city which were holding physical education classes during the same time of the day, but there were no reports of the incidence of patients from these schools. Differences in the amount of physical exercise or exposure time may be the reason but there is another conceivable possibility, that the casual substances may have been formed within a relatively localized area.

At any rate, the causal substances in Type C have the property of not necessarily being accompanied by the eye irritation symptoms.

As far as Type A (mainly the eye irritation symptoms) is concerned, it appears at first glance that there is a certain degree of correlation between the oxidant concentration and the complaint rate within a certain range of concentration, as with the difference in the complaint rates between the second incidence and the third incidence at school A. However, as it has been pointed out in the past, it would be difficult to explain the eye irritation symptoms in terms of ozone which is one of the main components of the oxidants, so that one would have to assume the case of substances other than ozone. The question here is the composition of the "oxidants". In the case of school A, the general correspondence with the oxidant concentration was probably exhibited because the second and the third incidences had occurred one after the other so that the composition of the pollutants did not vary considerably.

The characteristic of Type B is "coughing" and "sore throat" symptoms but the coughing in this case is not necessarily accompanied by sputum. Also, some of the students complained of chest pain accompanying the coughing. It would seem that the symptoms may be attributable to an acutely irritative gas. As far as the causal substance is concerned, could it not be a substance other than the casual substance of the eye irritation symptoms, a substance which is, furthermore, formed after the eye symptom causing substance is produced in view of the fact that the symptoms of this Type show a trend independent of the eye irritation symptoms and occur mainly in the fifth and sixth class periods? It should be noted in addition that although

we did not mention it in the body of this report, school A is situated next to another junior high school whose structural layout is more or less similar to that of school A. On the day of the first incidence, this junior high school was also holding similar physical education classes but did not report any damage. Although it has not been confirmed through investigation, some members of the faculty apparently had exhibited eye irritation symptoms, but at least, there were no students who had to be treated in the school clinic for severe coughing as there were at school A. It would therefore seem that the occurrence of the Type B symptoms was also localized to a considerable extent.

In addition, since the surveys were of the questionnaire format, there remains the question of the reliability of the symptoms entered. For instance, the occurrence of a serious symptom may result in the failure to enter in another relatively light symptom. Also, since question items are preselected, there is the risk of other more characteristic symptoms not being reported at all. These problems remain tasks for future research efforts.

5. Summary

Questionnaire surveys on subjective symptoms were conducted with respect to students of 2 junior high schools (A, B) where damage to health occurred apparently as a result of photochemical air pollution. The following results were obtained.

1. The analysis of the symptom distributions by the Category III quantification theory method (Hayashi) showed that the symptoms throughout the two schools could be classified into three types, namely (1) mainly eye

irritation symptoms (Type A), (ii) mainly coughing and sore throat (Type B), and (iii) predominantly nausea, dizziness and numbness of the extremities (Type C).

2. At school A, the complaint rate by class and the distribution of the symptoms were found to be correlated with the timing of the physical education classes for the first of the altogether three incidences of symptoms. To wit, the complaint rate increased and the symptoms shifted from Type A to Type B with the progression of the physical education class time. Some of the symptoms exhibited suggested transition to the Type C symptoms.

3. The symptoms for the second and the third incidences at school A were of Type A.

4. Throughout the three incidences, there was a recurrence of complaints particularly among the female students.

5. With respect to the Type C symptoms at school B, there was a difference in the complaint rate between the sexes.

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